Puget Sound Chinook

"Although it is natural for salmon populations to fluctuate from year to year, the dramatic fall in populations over the past century places remaining salmon stocks in jeopardy. Their reduced abundances allow no room for further downward cycles."

Tim McNulty, Olympic Peninsula Naturalist and Author

Chinook Life History

Truly the "King" of Pacific salmon, Chinook are the largest species with adults often exceeding 40 pounds; reports of adults over 100 pounds are common. Chinook at sea look similar to coho salmon (blue-green back with silver flanks), but are distinguishable by their large size, small black spots on both lobes of the tail, and black pigment along the base of their teeth.

Spawning and Incubation

As they prepare to spawn, Chinook lose their silvery color and appear battered from their journey. Chinook salmon typically spawn in larger streams and higher velocity areas with larger gravels than those areas utilized by the other salmon species. Depending on their evolutionary history, Chinook salmon may select spawning areas close to or even within estuaries, but their size and strength enable them to travel for hundreds of miles upstream in some river systems. Once the adult fish have arrived at the spawning grounds and "ripened," a female Chinook will dig a redd (nest) with her tail and deposit her eggs into four or five nesting pockets. The number of eggs for each Chinook female can range from fewer than 2,000 eggs to more than 17,000 eggs, but in Puget Sound it is estimated that 2,000 to 5500 per female is typical. One or more males will fertilize the deposited eggs, and the female Chinook will guard the redd from 4 to 25 days before dying. Males may seek other spawning opportunities before they too, expire. Depending on the water temperature, Chinook eggs will hatch between 32 to 159 days after deposition. Alevins (newly hatched salmon with attached yolk sacs) will remain in the gravel for another 14 to 21 days before emerging. Water quality, depth, velocity and temperature are all critical for the survival of eggs. Shallow water may make eggs more vulnerable to predators and disturbance. High velocity can cause scouring of the stream bed, dislodging the eggs from their redd. Puget Sound Chinook tend to have relatively large eggs, greater than 8.0 mm in diameter on average. (Croot and Margolis, 1991) (63FR11482; 3/9/98).

Rearing and Outmigration

The patterns for rearing and outmigration within the life history cycle of Chinook salmon vary widely, and scientists have identified four patterns just for juvenile Chinook. (See the Nearshore Chapter for a full description.) Juvenile Chinook salmon may move out of the freshwater area from their river of birth within 1 to 10 days after emerging from the streambed gravel, and spend many months rearing in the estuary, or they may reside in freshwater for a full year, spending relatively little time in the estuary area before migrating to sea. The majority of Puget Sound Chinook leave the freshwater environment during their first year, making extensive use of the protected estuary and nearshore habitats.

Chinook Population	% Outmigration During First Year min-max
NF Nooksack early	52-79
SF Nooksack early	40-73
Upper Cascade (Skagit)	28-91
Upper Sauk (Skagit)	29-65
Suiattle (Skagit)	16-77
Skykomish (Snohomish)	50-78
Snoqualmie (Snohomish)	58-94
Dungeness	29-100
Elwha	41-83
All others*	min >75%

*No data available for Hood Canal populations.

Figure 2.1 Puget Sound Chinook juvenile outmigration; percent of population that leaves freshwater in their first year (PSTRT members, pers. comm.; 2005

Figure 2.1 shows the percentages of the Chinook populations in Puget Sound rivers that leave freshwater during their first year. However, it should be noted that each of the populations exhibits a great deal of variation in the pattern of outmigration by juveniles.

Nearshore ecosystems provide areas for the young Chinook to forage and hide from predators. Juvenile salmon experience the highest growth rates of their lives while in the highly productive estuaries and nearshore waters. These estuarine habitats are ideal for juvenile salmon to undergo the physiological transition to saltwater, and to readjust to freshwater when they return to spawn as adults. Nearshore areas serve as the migratory pathway to ocean feeding areas. The vegetation, shade and insect production along river mouth deltas and protected shorelines help to provide food, cover and the regulation of temperatures in shallow channels. Forage fish spawn in large aggregations along protected shorelines, thus generating a base of prey for the migrating salmon fry. Salmon often utilize "pocket estuaries"-small estuaries located at the mouths of streams and drainages, where freshwater input helps them to adjust to the change in salinity, insect production is high, and the shallow waters protect them from larger fish that may prey on them. As the juvenile salmon grow and adjust, they move out to more exposed shorelines such as eelgrass, kelp beds and rocky shorelines where they continue their migratory path to the ocean environment.

Given adequate habitat, juvenile salmon experience the highest growth rate of their lives in the nearshore environment.

Age at Maturation

Chinook salmon exhibit considerable variation in their size and age of maturity. Coast-wide, Chinook salmon remain at sea for one to six years (more commonly two to four years), with the exception of a small proportion of yearling males (called "jacks") which mature in freshwater or return after two or

River Deltas provide vegetation, shade and insect production for food.

The freshwater input of **pocket estuaries** helps the salmon adjust to changing salinity.

Forage fish, which serve as prey for salmon, spawn in large aggregations along **protected shorelines.**

Exposed shorelines such as eelgrass, kelp beds and rocky shorelines serve as the migratory pathway to the sea.

three months in salt water. As shown in figure 2.2, Puget Sound Chinook tend to mature at ages three and four.

Migration

Chinook salmon generally migrate great distances in the ocean and tend to migrate to the north into waters adjacent to Canada and Alaska. It is thought that the diversity of migratory routes in the ocean may be important to the success of the species as a whole. During this migration, salmon that originated in many different rivers are mixed together, and separate themselves as they return to the proximity of their natal stream.

Although some Puget Sound Chinook apparently spend their entire life within Puget Sound, most migrate to the ocean and north along the Canadian coast. The migratory pattern of Puget Sound origin Chinook along the coast, rather than the open ocean, makes them particularly vulnerable to recreational and commercial fishing. Fisheries catch data indicate that most Puget Sound Chinook are caught in the Strait of Juan de Fuca, Strait of Georgia, Puget Sound and off of the west coast of Vancouver Island. Less than one percent are caught to the south of Cape Flattery, off of the west coast of Washington and Oregon.

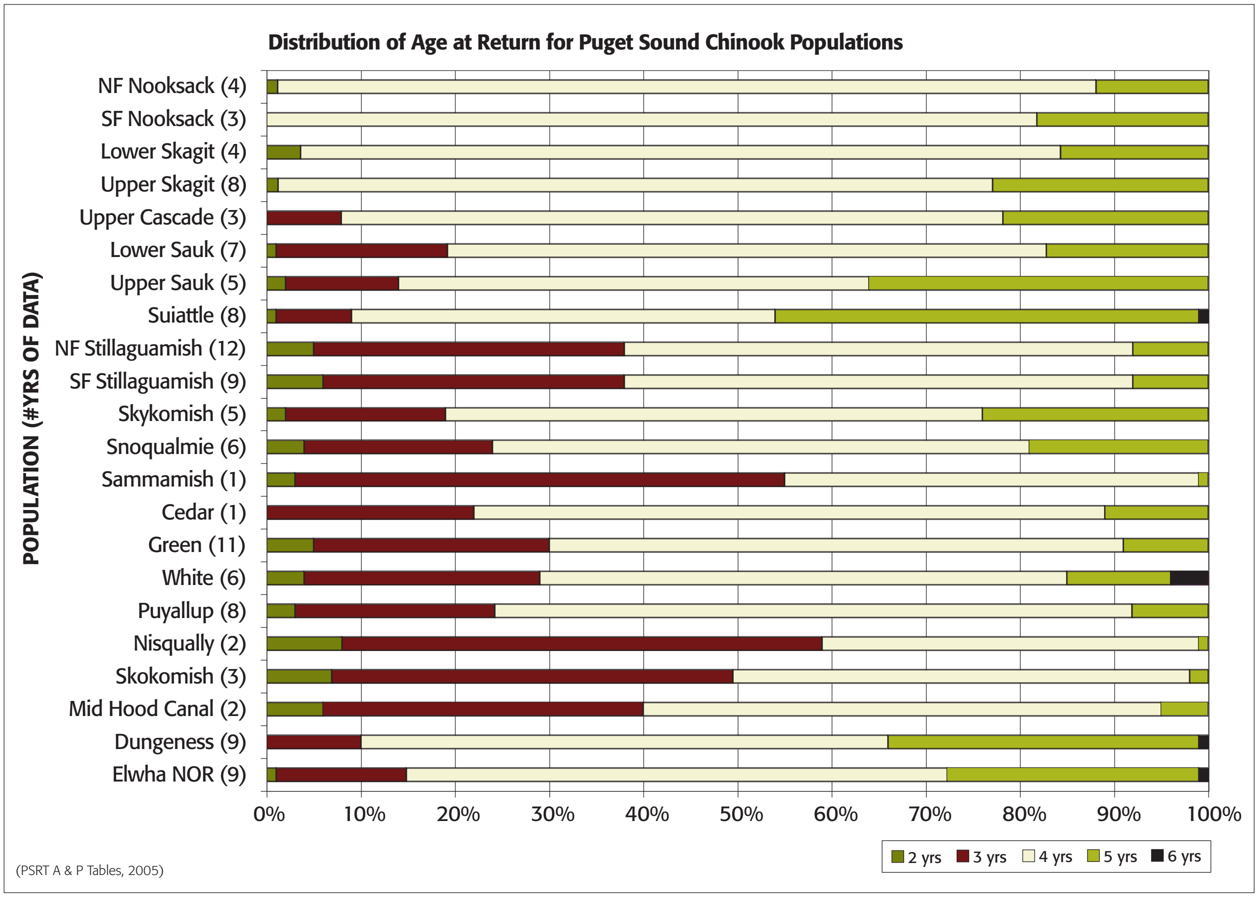
There appear to be substantial differences in migratory patterns between Chinook that originate from Puget Sound rivers and those from the Washington coast, with a higher proportion of coastal Washington Chinook migrating to Alaskan waters. While the Elwha River Chinook appear to be a transitional population between Puget Sound and coastal Washington stocks based on their genetic and life history characteristics, their migration patterns resemble Puget Sound Chinook more closely. Chinook from the northern rivers of Puget Sound, particularly the Nooksack, tend to utilize the Strait of Georgia more than other Puget Sound Chinook.

Puget Sound Chinook also vary in their return migratory routes from year to year, with different tendencies to migrate along the west coast of Vancouver Island or through Johnstone Strait and the Strait of Georgia. This may be a function of ocean temperature conditions and the effect of the large freshwater plume from the mouth of the Fraser River.

Timing of Returns and Spawning

Chinook salmon return to their streams of origin

Figure 2.2



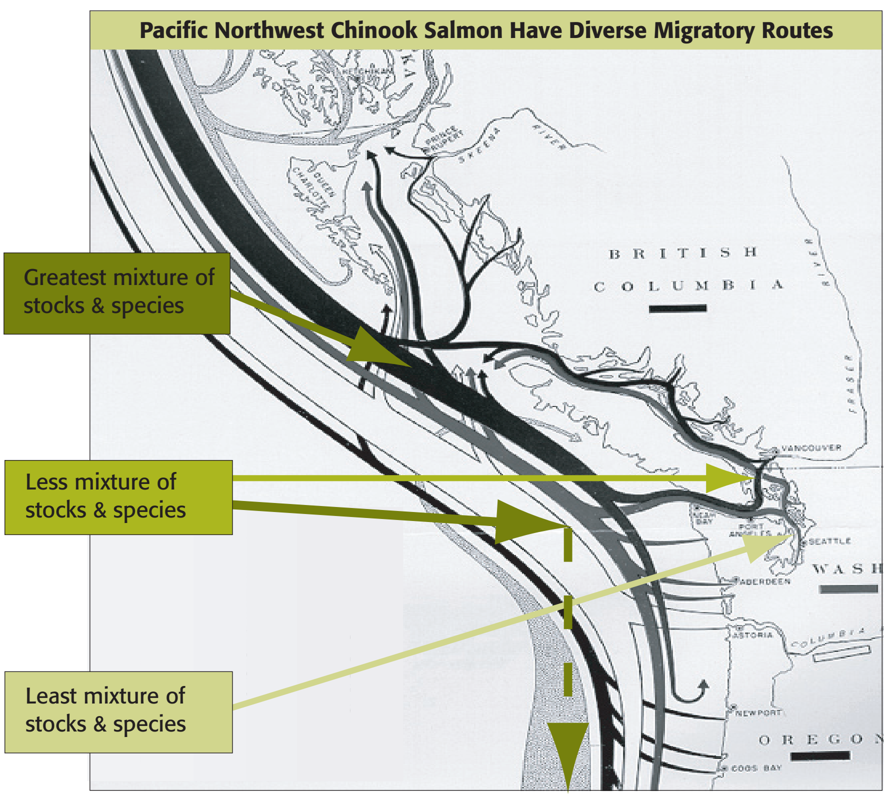


Figure 2.3 It is thought that the diversity of migratory routes in the ocean may be important to the success of the species as a whole. Image courtesy NWIFC.

with a high degree of fidelity. The "homing" characteristic is not perfect, and fish may stray to nearby streams with similar environmental characteristics, particularly when their home watershed has been disrupted. This trait may have helped spread their distribution across adequate incubation and rearing habitat, prevented catastrophic loss to the species based on a disturbance to one area or region, and provided a mechanism for local adaptation.

Although Chinook salmon may return to their natal river mouth almost any month of the year, peaks in run timing occur in the spring through late fall. The timing for Chinook re-entry to freshwater and spawning is believed to be related to local temperature and water flow regimes. "Despite the wide variation in run timing within most rivers, spawning times tend to be similar among runs." (Croot and Margolis, 1991) Egg deposition must occur at a time to ensure that fry will emerge during the following spring when the conditions in the river or estuary will provide food and refuge sufficient for their survival and growth.

Early-timed Chinook salmon tend to enter freshwater as immature fish in the spring, migrate far upriver, and finally spawn in the late summer and early autumn. Late-timed Chinook enter freshwater in the fall at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Myers et al. 1998). All stocks utilize resting pools, which provide a retreat from high-energy flows, thermal protection from late summer temperatures, and a safe haven from potential predators.

The return of adult Chinook salmon to freshwater in the Puget Sound region occurs from late March to early December, and varies considerably across and within major river basins (Figure 2.4). Peak Chinook spawning occurs from mid to late August to mid October. Chinook runs which return in the summer and fall predominate in Puget Sound, and many of the early-timed runs have become extinct. (Myers et al. 1998)

Status of Puget Sound Chinook

Following the status review of Chinook salmon from Washington, Idaho, Oregon, and California in 1998, the National Marine Fisheries Service deter-

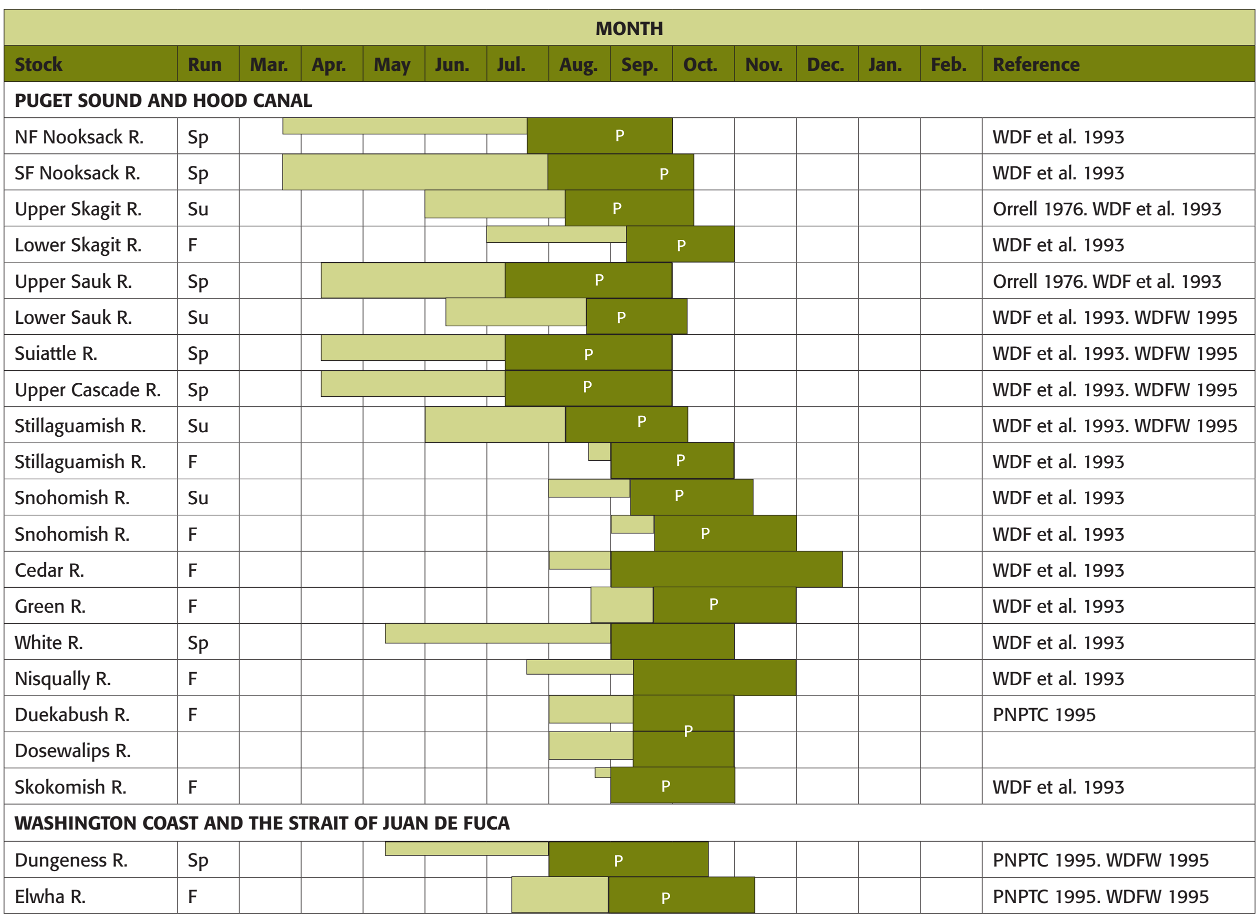


Figure 2.4 Freshwater migration and spawning timing for selected Chinook salmon from the Puget Sound. Run designations as characterized in the BRT Status Review, (Myers et al. 1998): Sp-spring; Su-summer; F-fall. Spring run designations for White and Dungeness Rivers stocks have been reclassified by local management agencies, but "Sp" labels have been retained for historical consistency. Due to variability in spawning times within a stock, some fish may still be entering freshwater during the spawning time intervals.

Freshwater Migration Timing
Spawning Timing

mined that Chinook salmon in the Puget Sound region constituted an evolutionarily significant unit and that the Puget Sound ESU is at risk of becoming endangered in the foreseeable future Myers et al. 1998). The Federal Register of March 9, 1998, which proposed the listing of Puget Sound Chinook as threatened under the Endangered Species Act, summarized the status of Puget Sound Chinook as follows:

"Overall abundance of Chinook salmon in the Puget Sound ESU has declined substantially from historical levels, and many populations are small enough that genetic and demographic risks are likely to be relatively high. Both long and short term trends in abundance are predominantly downward, and several populations are exhibiting severe short term declines. Spring Chinook salmon populations throughout this ESU are all depressed."

Populations, Metapopulations, Stocks and Runs

The dictionary definition of "population" is a broad term referring to a group of organisms that constitute a specific group and occur in a specified habitat. Ecology textbooks refer to populations as, "a group of organisms of the same species that occupy the same geographic area at the same time." Fisheries scientists have developed definitions for populations and related terms as follows:

- An **"independent population"** is defined as a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season.

- **"Metapopulations"** are the network of local populations or sub-populations that are genetically interrelated and in nearby geographic proximity. Their close relationships are thought to be the result of occasional straying by returning adult salmon to a neighboring patch of similar habitat within the same watershed or in a nearby watershed. The group of populations in an evolutionarily significant unit may be considered a metapopulation.

- In general, the term **"stock"** coincides with the definition of an independent population, referring to a local population of fish that originates from a specific watershed as juveniles and returns to the birth stream to spawn as adults. A stock is generally defined by its geographic spawning location, while a population takes into account genetic similarities as well.

- A **"run"** is generally the return of adult salmon in a given year for a particular species. A run may be further divided into timing segments such as an early run or a late run, and may refer to different geographic groupings, such as an individual river basin, or an entire region such as Puget Sound.

An evolutionarily significant unit (ESU) is defined by two criteria: 1) it must be substantially reproductively isolated, and 2) it must represent an important component of the evolutionary legacy of the species. The population definitions address the first of these criteria, but the evolutionary legacy component is based on additional considerations of genetics, geography and habitat adaptation.

(McElhany, et. al., 2000; PSTRT, 2005; National Research Council, 1996)

The Puget Sound Evolutionarily Significant Unit

The Puget Sound ESU is a composite of many individual populations of naturally spawning Chinook salmon, and a number of hatchery stocks (64FR 14308, 3/24/99). The delineation of the independent populations that make up an ESU is a major step in the development of a recovery plan, as the populations are the building blocks for persistence and recovery. The boundary of the Puget Sound Chinook salmon ESU extends from the Nooksack River in the north to southern Puget Sound, includes Hood Canal, and extends westerly out the Strait of Juan de Fuca to the Elwha River. The Skagit River and its tributaries constitute what was historically the predominant system in Puget Sound containing naturally spawning populations.

Independent Populations of Puget Sound Chinook

Recently the Puget Sound Technical Recovery Team (PSTRT) analyzed the Chinook populations of Puget Sound and identified 22 independent populations of Chinook salmon (figure 2.6). The population designations are preliminary, and may be revised based on additional information. The scientists looked at previous work in the Salmon and Steelhead Stock Inventory (WDFW et al., 1993) and other data to identify geographic boundaries of historical populations of Chinook. The PSTRT evaluated factors including the location of spawning habitat, the extent of straying by adult Chinook to spawning sites away from their natal stream or location, genetic attributes, patterns of life history, and other population and environmental characteristics. The report, Independent Populations of Chinook Salmon in Puget Sound (PSTRT, 2005), emphasized that the geographic boundaries of independent populations identified in the report do not include all of the habitats that may be important to population viability or recovery of the ESU.

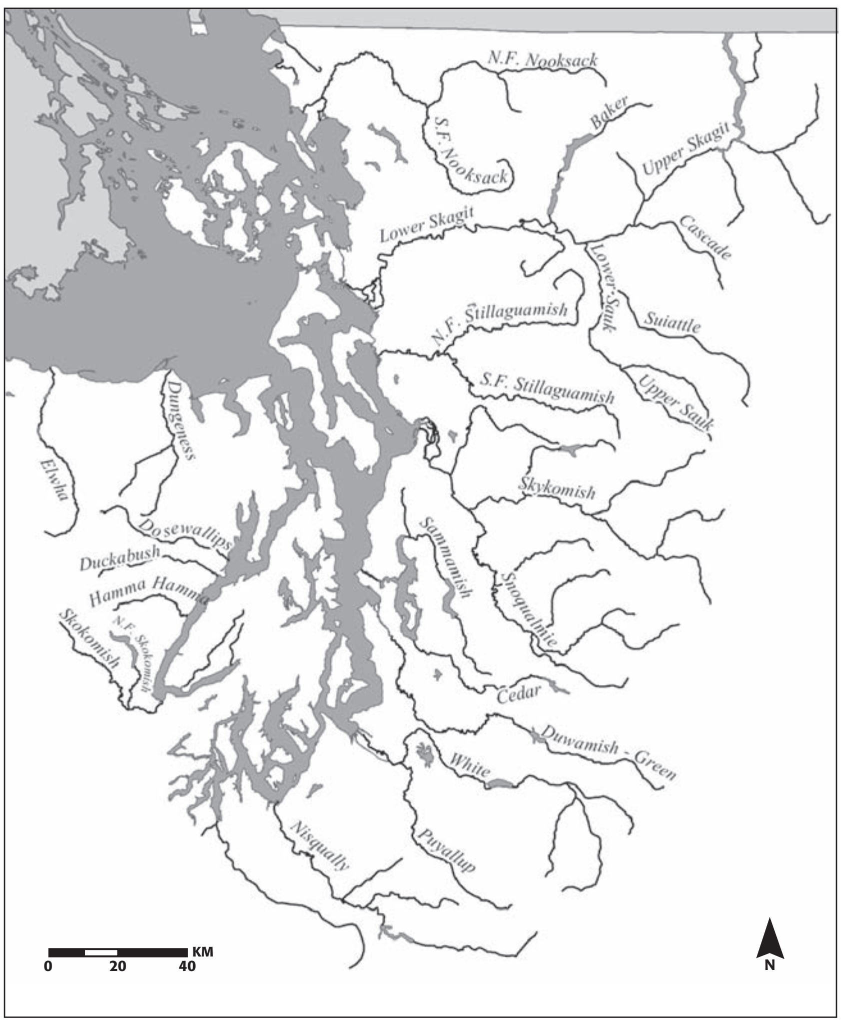


Figure 2.5 Major Chinook salmon spawning rivers and tributaries in the Puget Sound (PSTRT, 2005)

Extinct and Extant Chinook Populations

Although 22 independent populations of Chinook salmon have been identified in Puget Sound, historically it is believed that there may have been 30-37 independent populations or spawning aggregations. Chinook populations that have been particularly affected are the early returning life history types in the Puget Sound ESU. As noted by the West Coast Salmon Biological Review Team in their 2003 report, "The loss of early-run Chinook salmon stocks in Puget Sound represents an important loss of part of the evolutionary legacy of the historical ESU." (Myers et al. 1998)

The historical presence of early Chinook runs is supported by anthropological reports from the early 20th century, which noted that local tribes fished for salmon almost year-round, moving throughout Puget Sound to take advantage of the run timing on different river systems. As steelhead fishing wound down in the late winter, tribal fishers would look

Figure 2.6 Independent Populations of Puget Sound chinook (PSTRT, 2004)

forward to the early Chinook runs in the large rivers (Gunther, 1927).

Genetic Characteristics

An analysis of the genetic structure of groups of Chinook populations on the West Coast of the United States was conducted by the NMFS West Coast Chinook Biological Review Team during their 1997 status review. Puget Sound populations of Chinook salmon constituted a genetically distinct group from other chinook along the west coast of the United States and Canada. The Elwha River population was genetically intermediate between Puget Sound and Washington coastal populations. Populations from the Nooksack system were genetically very distinct, probably due to their location on the northern boundary of the Puget Sound eco-region, but were more closely allied with other Puget Sound samples than with populations from the Washington coast or Canada.

Further analysis of genetic differentiation among Puget Sound Chinook populations was conducted by the Puget Sound Technical Recovery Team (PSTRT, Technical Memo Draft, 2005). Six major genetic clusters of Chinook salmon in Puget Sound were identified, which were generally consistent with the geographic configuration of the river systems:

1. Strait of Juan de Fuca Chinook Salmon
2. Nooksack River early-returning Chinook salmon
3. Skagit and North Fork Stillaguamish Rivers Chinook salmon
4. Snohomish and South Fork Stillaguamish Rivers Chinook salmon
5. Center, southern Puget Sound and Hood Canal late-returning Chinook salmon
6. White River early-returning Chinook salmon

River Basin	Independent Populations	Putatatively Extinct Populations or Spawning Aggregations
Nooksack	North Fork Nooksack * South Fork Nooksack *	Late-run Nooksack
Skagit	Lower Skagit Upper Skagit Cascade* Lower Sauk* Upper Sauk* Suiattle*	Baker River
Stillaguamish	North Fork Stillaguamish South Fork Stillaguamish	Early-run Stillaguamish
Snohomish	Skykomish Snoqualmie	Early-run Snohomish
Lake WA	Sammamish Cedar	Late-run Sammamish
Duwamish/Green	Duwamish/Green	Early-run Duwamish/Green
Puyallup	White* Puyallup	Late-run White Late-run Puyallup Early-run Puyallup
Nisqually	Nisqually	Early-run Nisqually Late-run Nisqually
Skokomish	Skokomish	Early-run North Fork Skokomish Early-run South Fork Skokomish
Dosewallips, Duckabush, Hamma Hamma	Mid-Hood Canal	Early-run mid-Hood Canal
Dungeness	Dungeness	
Elwha	Elwha	Early-run Elwha
*indicates early-run timing		

Figure 2.7 List of extant independent populations of Puget Sound Chinook salmon and populations or spawning aggregations thought to be extinct. (PSTRT, 2005)

The genetic composition of Chinook in some Puget Sound systems, particularly in Lake Washington and the South Sound, has been extensively influenced by hatchery stocks. Evidence of historical variation has also been constrained by dams on some Puget Sound Rivers. The Elwha River, for example historically contained a population of the largest Chinook salmon in the Puget Sound area; it is not clear whether these fish have any remaining genetic legacy in the Elwha River population (PSTRT, 2001; 63FR11484, 3/9/98).

Viable Salmon Population Parameters

A **"Viable Salmon Population"** has been defined by NMFS as "an independent population of any Pacific salmonid that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year time frame." (McElhany et al., 2000)

Four parameters have been identified to assess the viability of salmon populations: abundance, productivity, spatial structure and diversity. NMFS focuses on the four parameters for several reasons. They are reasonable predictors of extinction risk, they reflect general processes that are important to all populations of all species, and they are measurable. VSP parameters can be applied at the population and ESU level.

"Abundance" is simply the size of the population. NMFS considers abundance important because, "all else being equal, smaller populations are at greater risk of extinction than large populations."

"Productivity" refers to the population's growth rate and how well the population is performing, and is generally measured by the number of returning adults produced by a parent spawner. If the estimates of productivity indicate that a population is consistently failing to replace itself, it is an indicator of increased extinction risk.

"Spatial Structure" refers to the distribution of the fish in a population or group of populations in the habitat they use throughout their life cycle. A population that has a greater spatial distribution of individuals is more likely to persist than a population whose individuals are concentrated in a few locations. Spatial structure of fish populations goes with the habitat that supports them. Habitat patches are needed by salmonids at all life history stages in a distribution pattern that does not increase the risk of a catastrophic loss. The populations and their habitat must be close enough to allow individuals or populations to connect to each other or to re-colonize an area that has become extirpated.

"Diversity" indicates the differences within and among populations in genetic and behavioral traits, such as run timing, age structure, size, etc. Diversity allows a species to use a greater variety of habitats, and allows it to survive short and long term changes in the environment from natural or human-caused factors.

Although the VSP parameters have been specifically developed for salmon, a chicken farmer might think of them this way: 1) Is the flock abundant enough that it can withstand some loss from foxes and hailstorms, and prevent inbreeding? 2) Are the chickens producing enough eggs to replace themselves over the long term and provide a living for the farmer? 3) Are you keeping all your eggs in one basket? Do you have enough egg-laying boxes and roosting posts for the size of the flock? Do your chickens have enough room to avoid fighting and competing for territory? 4) Is your flock diverse enough in its different breeds and age groups that it is likely to persist for a long time, even if environmental conditions around the coop change?

Recent Population Abundance and Productivity

Several populations of Chinook salmon in the Puget Sound ESU have experienced critically low returns within the last 20 years. Chinook populations in the Nooksack, Lake Washington, mid-Hood Canal, Puyallup and Dungeness basins have had returns of less than 200 adult fish, placing these populations at substantial genetic and demographic risk. Only two populations, the Upper Skagit and Green/Duwamish have had average returns in excess of 10,000 adult Chinook for the most recent five year (2000-2004) period. Figure 2.8 displays geometric means for the abundance of naturally spawning Chinook populations for selected five year periods.

Figure 2.8 also contains information on the contribution of hatchery-origin fish to the natural spawning populations. Of the twelve populations with greater than 1,000 natural spawners for the most recent five year period, only the two Skagit populations are thought to have a low fraction of hatchery fish (<5%). (Note that fish which were incubated and released from a hatchery, referred to as "hatchery-origin" fish, may return to spawn naturally. Data which would help scientists differentiate between those fish which incubated naturally in streams, and those returning adults which were

	1986-1990			1994-1998			2000-2004	
Populations	Geometric Mean	% Hatchery Contribution	Productivity	Geometric Mean	% Hatchery Contribution	Productivity	Geometric Mean	% Hatchery Contribution
North + Middle Fork Nooksack	140	21%	1.29	263	67%	0.45	4,232	94%
South Fork Nooksack	243	7%	0.60	181	35%	1.20	303	46%
Lower Skagit	2,732	1%	0.59	974	1%	3.15	2,597	2%
Upper Skagit	8,020	2%	0.69	6,388	1%	1.60	12,116	4%
Upper Cascade	226	0%	0.88	241	0%	1.34	355	1%
Lower Sauk	888	0%	0.61	330	0%	2.35	825	0%
Upper Sauk	720	0%	0.57	245	0%	1.35	413	0%
Suiattle	687	0%	0.40	365	0%	1.20	409	0%
North Fork Stillaguamish	699	0%	0.92	862	35%	0.94	1,176	31%
South Fork Stillaguamish	257	0%	1.31	246	0%	1.22	205	0%
Skykomish	3,204	14%	0.52	3,172	52%	0.82	4,759	39%
Snoqualmie	907	12%	1.23	1,012	33%	1.68	2,446	14%
Sammamish	388	41%	0.28	145	74%	2.72	243	69%
Cedar	733	9%	0.51	391	17%	0.97	412	21%
Green/Duwamish	7,966	62%	0.50	7,060	71%	1.00	13,172	34%
White	73	56%	7.51	452	82%	1.49	1,417	28%
Puyallup	1,509	15%	1.86	1,657	40%	0.67	1,353	31%
Nisqually	602	3%	4.22	753	21%	1.38	1,295	25%
Skokomish	1,630	69%	0.48	866	69%	0.34	1,479	80%
Mid Hood Canal	87	26%	1.41	182	26%	1.31	202	46%
Dungeness	185	83%	0.12	101	83%	0.70	532	83%
Elwha Nat Spawners	2,055	34%	0.46	512	61%	1.03	847	54%
Elwha Nat+Hat Spawners	3,887	34%	0.67	1,679	61%	1.27	2,384	54%

Table Notes: Data from TRT A&P Tables 4/15/05.
No estimates of productivity are included for 2000-2004 period, since returns from those spawning (brood) years are not complete. The1986-1990 period represents the first 5 year period for which escapement data is available for all populations. The 1994-1998 period is the 5 years prior to listing (in March 1999). The 2000-2004 period is the last 5 years for which we have escapement data (most recent 5 years).

Figure 2.8 Geometric mean (5 yr periods) of natural spawning abundance, % hatchery contribution to natural spawners, and productivity (return spawners from parent spawners) for Puget Sound Chinook populations.

hatchery-origin fish that returned to spawn naturally, are unavailable in several river systems.)

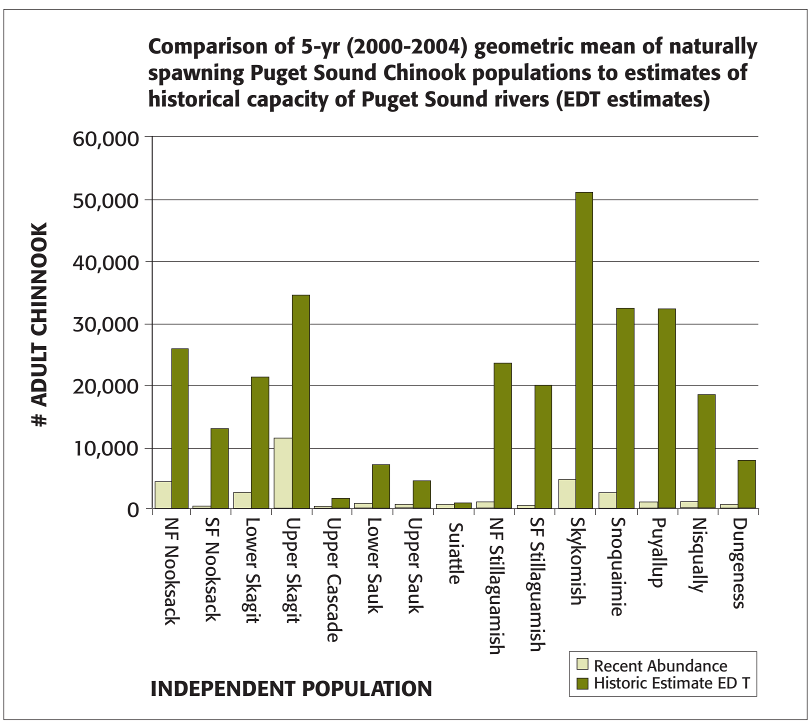
The productivity estimates in figure 2.8 are the number of adult offspring that return and spawn successfully from a single parent spawner. A figure of 1.0 indicates that the population is replacing itself. Figures shown in red represent productivity values below the population replacement level. It should be noted that productivity is calculated on the basis of parent year to offspring returning over several years, and the trends of mean annual abundance may not be the same as those for productivity.

Although the status review of Puget Sound Chinook conducted in 1998 (Myers et al.) indicated that the long term productivity trend for naturally-spawning populations was declining by 1.1%, more recent information has shown some improvement. The updated trend calculated in 2003 was flat, suggesting that the populations are, on average, just replacing themselves (NMFS/BRT, 2003). Productivity in many populations has increased, although it may still be below the replacement value. However, it should be noted that it is difficult to determine these trends due to the presence of hatchery-origin fish in the naturally spawning populations.

In order to compare recent abundance figures with historical run sizes, scientists have used a number of methods to estimate the historical population levels. One method is the Ecosystem Diagnostic Treatment (EDT) computer model (Mobrand, Inc.) which allows biologists to input the size and quality of habitat capacity to estimate the number of salmon that the river system could support. EDT modeling results support other records and observations over the last century, and indicate that present Puget Sound Chinook populations are a small fraction of their historical levels.

Viability of Puget Sound Chinook Populations and the Puget Sound ESU

Based on the four Viable Salmon Population (VSP) parameters, few of the Chinook salmon populations in Puget Sound are considered to be viable. With the exception of the Skagit system, abundance levels in each of the populations are a small fraction of their historical estimates. Productivity in many cases has been declining, or remains below the population replacement value. Although the spatial distribution of naturally-spawning populations is difficult to determine due to hatchery influence, the remaining populations with significant numbers of natural-origin spawners are concentrated in the region containing the Skagit and Stillaguamish River basins. Diversity has been impacted



Notes on graph: EDT estimates of historical capacity of Puget Sound streams are taken from the 2003 Status Report by the NMFS Biological Review Team, which was based on unpublished data from the Puget Sound TRT and Puget Sound co-managers.

Figure 2.9 is a sampling of historical estimates for the 15 Puget Sound chinook populations for which EDT analysis was available.

Viability at the ESU Level

In considering the viability of an entire ESU, consideration must be given to additional factors such as catastrophic events that eliminate an entire population, long-term demographic processes that allow populations to colonize new or restored habitat areas, and long-term evolutionary potential. ESU viability guidelines include:

- ESU's should contain multiple populations.
- Some populations in an ESU should be geographically widespread.
- Some populations should be geographically close to each other.
- Populations should not all share common catastrophic risks.
- Populations that display diverse life histories and other attributes should be maintained.
- Some populations should exceed minimum VSP ranges.
- The level of uncertainty about ESU-level processes should be taken into account.

(McElhany, et al., 2000)

by the loss of many of the early-run Chinook populations, underscoring the importance of preserving the remaining early populations. (FIgure 2.7).

Section 4 of the Recovery Plan contains a discussion of the technical guidelines and planning ranges for abundance in determining whether an individual Chinook population can be considered to be viable, and thus at a low risk of extinction.

A viable ESU is similar to a viable population--it is naturally self-sustaining and has a negligible risk of extinction over a time period of more than a century. Guidelines for the ESU level are also similar to those for individual populations, and focus on the risk of catastrophes, maintenance of population processes, and preservation of diversity. These guidelines are described further in Section 4.